Stars and Discoveries

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BIOGRAPHIES

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Presently is the Education Coordinator at the Planetarium C. Gulbenkian - Ciência Viva Science Centre in Lisbon. Has a background in Chemistry Engineering, Degree in Physics and Chemistry Teaching, Master in Pedagogical Supervision and several trainings in NASA, ESA, CERN, Eurofusion, RAL-lasers, Science Museums and Planetariums. Works on (and learns about) Science Education, Space Sciences, Astronomy and Science Communication.

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Presently, is a Principal Researcher at the Instituto de Educação da Universidade de Lisboa. She has been developing research in science teaching, namely in promoting a closer relationship between formal and non-formal science learning contexts (science centres and museums). Has a PhD in Biology and a PhD in Science Education.

ABSTRACT

Stars and Discoveries describes a planetarium program visit with a mobile App Roadmap of the Discoveries. This free downloadable App is a cultural and scientific tour exploration offering different itineraries through a set of museums, monuments and places in the city of Lisbon, all related with the Portuguese Discoveries. When visiting the Planetarium participants explore the itinerary Trough the Sea: night sky watch, ships, sky maps, telescopes and astronomical navigation instruments as used by the Portuguese Navigators from the 15th century are some of the ingredients of this experience. With no disciplinary subjects, this itinerary involves and engages visitors through scientific ideas, experiences and emotions, characteristics of non-formal education in a planetarium science centre.

INTRODUCTION

We describe a planetarium visit program to promote science literacy guided by the mobile App Roadmap of the Discoveries. This is part of a wider project with the same name created in the Science Education Department of the Institute of Education of the University of Lisbon (http://www.ie.ulisboa.pt/didatica-das-ciencias/app-roteiro-dos-descobrimentos).

It also includes other visit programs to a Museum, an Aquarium and walk paths through some historical monuments and old districts of the city.

Roadmap of the Discoveries uses the richness of content and new ideas of the Age of the Discoveries in the 15th century when Portugal began the process of globalization from its capital, Lisbon. At that time, Portugal was a country with a small population of slightly more than 1 million people and yet, Portuguese were among the first ones to connect the World through the sea. One may say they were the founders of the first global worldwide “internet”. Perhaps, the human crusade closest to the actual Space Exploration was the Portuguese Expansion, in the sense that the human kind steps into an abyss of unknown in search for new lands. At that time, instead of space ships and gps there were caravels and astronomical navigation. These cross ideas are in the core of Portugal History and Culture, involving subjects from areas such as science, technology, mathematics, biology, geography, business and languages. Moreover, these contents are learning targets of the Portuguese school curriculum.

The App Roadmap of the Discoveries with its several Itineraries is scientifically validated and a tested learning resource for STEM (Science, Technology, Engineering and Mathematics). Mainly targeting school groups, this visit program is also recommended for families or other groups, in a non-formal science learning context such as the Planetarium.

Trough the Sea is the itinerary to visit the Planetarium Calouste Gulbenkian - Ciência Viva Science Centre and resulted from the cooperation between the Institute of Education of the University of Lisbon and the Education Coordinator of the Planetarium.

This Planetarium, a 23 meters diameter dome in Lisbon, was built due to Commandant Conceição Silva, officer of the Portuguese Navy for sky watching and to teach astronomical navigation techniques to young cadets of the Military Navy School.
With ships, maps and astronomical navigation instruments as used by Portuguese navigators and, through an inquiry-based science learning (IBSE) methodology, the Education Department of the Planetarium takes participants in an adventurous story they will remember long after their visit.

Learning outside the classroom, associated to the IBSE methodology, favors the contact of students with problems and challenges of their daily life, contributing to a better understanding of science and the scientific process.

The museum environment provides opportunities for youth to connect with science in personally meaningful ways, develop their own science identities and consider pursuing science careers (Adams & Gupta, 2013; McCreedy & Dierking, 2013). Curriculum expanded learning environments comes alive in planetariums, forest and nature, parks, libraries, market place, Science centers and museums, aquariums, homes for the elderly, etc.

Learning outside the classroom also promotes motivation, creativity, critical thinking and the ability to work as a team. Participants begin to ask questions and to seek answers as they engage with content (Renninger, 2007).

I. THE PROJECT ROADMAP OF THE DISCOVERIES

The Portuguese Age of Discoveries began with the Infant D. Henrique and the conquest of the African coast, having elapsed during the reign of D. João II, with the discovery of the maritime route to India and the reign of king D. Manuel I, during which the overseas empire was already consolidated. This historical process made a decisive contribution to the knowledge of the world and the relationship between its many civilizations.

Roadmap of the Discoveries can be explored in a family or in a school context for children 4-6th grades. It is based on a free computer application for Android system mobile technology devices (Fig. 1).

![Figure 1 – Roadmap of the Discoveries: a project to learn Science](image)

It proposes the exploration of some monuments, institutions and places of the City of Lisbon associated to the period of the Portuguese Discoveries, between the 15th and 16th centuries. It offers several possible itineraries, taking place in different Monuments and Museums of the city, focusing on the History, the encounter of different Cultures and Languages, the Astronomical Navigation and the Biodiversity of the Oceans.

For the production of the educational contents, partnerships were established between the Institute of Education (University of Lisbon) and three non-formal Education Departments (Planetarium Calouste Gulbenkian - Ciência Viva Science Centre, Museum of the Orient and Aquarium Vasco da Gama).

The production of the App Roadmap of the Discoveries was coordinated by the Institute of Education of the University of Lisbon in partnership with the Department of Informatics of the Faculty of Sciences of the University of Lisbon, which was responsible for creating the software application for mobile Android system.

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The App can be downloaded from Google Play Store here:


The visit itineraries of the Roadmap of the Discoveries are the following:

1. Itinerary Trought the Sea – Planetarium Calouste Gulbenkian – Ciência Viva Science Centre

This dimension addresses issues associated with astronomical navigation. Here participants are led to discover the differences between a caravel and a ship, the astronomical navigation instruments used in maritime trips and their function, the references found by navigators to sea orientation, the importance of astronomy and constellations and the cardinal points. They explore life on board, including issues such as food (storage and conservation) and hygiene (scurvy, for example, a disease attacking sailors due to lack of vitamin C).
2. Itinerary Monsters and other marine creatures - Aquarium Vasco da Gama
This itinerary addresses marine biodiversity of the different oceans sailed during the sea voyage from Portugal to India. It includes 3 stations:
The first one corresponds to the fish gallery of the Portuguese coast, promoting students’ understanding about the morphological characteristics of fishes associated with their way of life and habitat.
The second station corresponds to the area of the museum of the Aquarium and it is intended that students learn about marine mammals, live species and their main threats. Students must associate some of these marine mammals with known marine mythological monsters.
The third station runs in coral and tropical fish aquariums area, introducing students to some species of coral, the importance of coral reefs and its current threats. The question, why in Portugal there are no coral reefs is also raised.

3. Itinerary The City at the time of the Discoveries
Three routes related to this dimension are carried out in various places in the city of Lisbon.
The first in Belém, along with the main monuments associated to the Portuguese Discoveries, including the Jerónimos Monastery, the Tower of Bethlehem and the Monument to the Discoveries. A photographic Pedy paper game acquaints participants with the importance of some Portuguese figures who stood out in this period, and promotes the exploration of the Manueline architectural features and the Portuguese colonization symbology.
The second station corresponds to Mouraria and Alfama, two historical districts of Lisbon, where students are expected to discover architectural elements of the Manueline period. Sixteens points can be visited and participants have some observation tasks associated to some of them.
The third station includes downtown: Commerce Square, Ribeira das Naus and Rossio. In this course, students are invited to discover how the city of Lisbon was like in the fifteenth century, comparing it with present-day. Issues such as transports, clothes, the type of events held and the organization of the city are focused. For example, the analysis of the painting “Panels of São Vicente de Fora” shows the different social groups existing at the time.

4. Itinerary People and Cultures – The entire World in Lisbon
This dimension addresses aspects related to cultural diversity and the encounter of cultures through the voyages made during the time of the Discoveries.
Two of these routes are in Martim Moniz and Mouraria, two historical districts. One is related to language diversity in that area where it is possible to observe records written in different languages. Participants are asked to associate them with a type of alphabet: Latin, Cyrillic, Greek or Hebrew. Along the route, students may associate countries to the respective languages, from the 51 nationalities present in this area of the city, and explore a little more about the Portuguese language (which is also spoken in other countries). Students will also analyze Chinese characters and will try to decipher some of the proposed challenges. The second route takes place in the same area and takes an approach to the Hindi language and Indian culture, having gastronomy as a background.
The third route takes place in the Museum of the Orient including a visit to the exhibition “Portuguese Presence in Asia”. Here it addresses some important Portuguese figures of the time of the Discoveries (Luís Vaz de Camões, Fernão Mendes Pinto, Vasco da Gama) and some aspects of the different culture characteristic of some countries where the Portuguese lived and had commercial connections (India, Japan, China, Macau).

II. THE VISIT TO THE PLANETARIUM
The visit program to the Planetarium has two learning activities: Sailing with the stars (under the dome) and Astronautical Navigation Instruments (outside the dome). This visit includes guidance on the mobile App (Fig. 2) as well as a planetarium show (optional). Both learning activities were developed by the Education Department of the Planetarium.

Figure 2 – Exploring the itinerary Roadmap of the Discoveries App
Under the planetarium dome, Sailing with the Stars, requires a live show to perform this adventure from the 15th century under a starry night sky (including constellations, Polaris, meridians, Equator). Live shows are more recommended to school visits
and contribute to better fulfil public visitors’ expectations. However, it is important to have a good presenter to succeed in promoting interaction and answering questions from the audience. We combined the live show with two other elements: the interaction of participants (who have to move around the central area of the planetarium to “sail” and have to locate some constellations with the support of transparencies) and some audiovisual effects (video of a ship sailing rough sea, waves and wind, clouds interfering with sky gazing, sound waves, thunder storm, sea sounds, etc.).

II.1 Under the dome - Sailing with the Stars
The activity starts with an invitation from the presenter to participants: “let’s go back in time” and a story begins… It all began in the 15th century when the European Maritime Expansion started. Most people lived in poverty. Between the periods of famine, disease and war, of that period of the History of Europe, people and countries sought for richness and power. Within this context, the Portuguese Age of the Discoveries was a whole national movement leading a wide range of expeditions to the ocean in order to increase territory and influence. Most peasants knew from their childhood that a life of hard labor and possibly years of poverty was the most likely to expect. On the other hand, some of them acknowledge new alternatives, like joining the military or joining a sea expedition to the “unknown”.

In the early 1400s, sailing needed to have the coast in the range of sight for guidance. The navigation far from the coast would only be possible with the reference of the stars by night or, the presence of the sun during the day. So, an urge to develop observation techniques, instruments and maps and the so-called astronomical navigation soon led to technological breakthroughs. Not only did the instruments become more sophisticated, ships and vessels got larger and faster, but also food storage and preservation techniques, medicine and hygiene developed greatly.

Participants take a role play: they are just poor people from the 15th century “…You don’t know how to write or read, you don’t have a mobile, internet, medicines, vaccines, medical care, electricity, clean water piped and no decent roof, …, you are very poor, you may even have to steel to put some food in your children’s mouth…”

Let’s go on board … and come back home rich!

A brief discussion is promoted with participants about arrangements for the expedition: food, water, equipment, etc. During the sea travel we sailed across deep seas, far … far away from the coast. Like navigators from the Age of Discovery, we managed to guide our ships under the stars!

Participants have to look up for constellations, for example, Cygnus or Orion (Fig. 3). They understand the meaning of a constellation and of an asterism. They have to find North so they learn how to locate the Big Deeper, the Small Deeper and the Polar Star.

They identify and locate some other constellations in the Northern Hemisphere.

Figure 3 – Searching for constellation patterns in the night sky under the dome of the planetarium

The Western European culture, inherited from the Greek and Romans, imagined gods and mythological characters in the night skies, whilst other cultures in the world watched the same stars but imagined different images and constellations. “Days, weeks, even months pass by … The sea is rough and the sound of waves is loud … storm is coming … With luck, after the storm fades we hope to have a clear sky to find our way guided by the stars or by the sun … And let us pray for good winds… The Polaris is going down and down on the horizon …the Line of the Equator is right above our heads … new stars and new skies come on sight… Where are we going to? Reaching the Southern Hemisphere, we meet the unknown. A whole new sky is above us.”

Participants sail across the ocean guided by the stars just like in the Age of Discovery navigators did. Towards the South they discover new stars, feel the need for new references and create new constellations. Then, turning South Cape of Africa from the Atlantic Ocean to the Indic Ocean, they overcame the Cape of Storms later named Cape of Good Hope!

Participants understand the role of Astronomy, constellations or cardinal points to navigate across the seas. The presenter has to ensure the viewpoint is correct to observers’ location as they travel along Earths’ surface. He shows the night sky, points out some constellations and talks about how and why our viewpoint changes. One last subject focused in this activity is to observe the light pollution’s effect on the night sky and perceive the factors that produce it and other related issues. All steps of this activity should be simple to set up with any adequate planetarium software.
II.2 Outside the dome - Astronautical Navigation Instruments

The position of the Sun in the sky guided sailors along the sea travels. But how did they managed to find the right direction and don’t lost themselves in the large oceans? Which instruments did they use? Let's put hands-on to build a quadrant, to learn how to use an astrolabe, to measure the height of the Sun, know the latitude and also observe our star through the telescope!

This hands-on and minds-on activity uses some navigation instruments as used in the 15th century (Fig. 4). Participants build simple quadrants and learn how to use it by measuring the height of the Sun. They also learn to use an astrolabe and compare measurements, noticing complementarity between the two instruments in a way they minimize reading errors. Then they learn to read Sun Declination Tables to succeed to calculate the local latitude.

During this activity participants watch the Sun through a telescope equipped with filters and interact each other and with the mediators. It is very important that mediators give communication opportunities to participants. For this activity we use calibrated copies of original astrolabes and quadrants from the collection of the Maritime Museum of Lisbon. To build the quadrants we use the Kõr Latitude & Longitude, an education resource from Ciência Viva® available online here: http://www.cienciaviva.pt/equinocio/

III. EVALUATION AND SOME FINAL IDEAS

The App Roadmap of the Discoveries takes users in a continuity of activities across multiple locations, which is an affordance for learning that mobile devices can provide. It may be explored autonomously by the user. Based on on-site observations and historical information, a diversity of tasks was developed in the App: drawing, interpreting writing messages, connecting ideas, observing, classifying, selecting information, assembling puzzles, previewing and reasoning. For student groups there are some classroom challenges like planning and researching, to do before or along the visits.

An evaluation study of this App was done by the team researchers of the Institute of Education of the University of Lisbon. A participant observation of 8 teachers and 131 students (8 and 11 years old) has been carried on to understand students’ and teachers’ opinions. A questionnaire about the use of the mobile phone, aspects that they liked, difficulties felt and aspects that facilitated learning, as well as lessons learned was applied. Moreover, a semi-structured interview to teachers and to groups of 5-6 students brought up information about the application popularity, the impact on learning and about the use of technologies during teaching and learning processes.

The results about what students learned provided evidence that this App is a relevant didactic resource to teachers and other professionals, who use digital games in a learning context. The App showed to be a different way for students to have contact with the information and with different historical contents associated with the various monuments, also implying cooperation between peers to overcome the different challenges proposed. It took students to discover their city. Some students told that they showed their parents the App and that they showed surprised by what they have learned. Teachers even stated it has been gratifying to have had this opportunity with their students.

Students also emphasized a greater interest in learning, as they felt they were active participants throughout the visit, as well as, getting new perspectives and overcoming some challenges showed to be more interesting than just looking or hearing someone speaking during a visit.

According to the 2014 U.S. Mobile App Report, 60% of digital media time in the U.S., for instance, takes place on mobile devices. This represents an opportunity for the field of informal STEM education to reach children where they are already spending time.

Moreover, the OECD (2015) stated that technology can support new pedagogies that focus on learners as active participants with tools for inquiry-based pedagogies and collaborative workspaces. For example, technology can enhance experiential learning, foster project-based and inquiry-based pedagogies, facilitate hands-on activities and cooperative learning, deliver
formative real-time assessment and support learning and teaching communities, with new tools such as remote and virtual labs, highly interactive non-linear courseware based on state-of-the-art instructional design, sophisticated software for experimentation and simulation, social media and serious game.

It seems that we are only in the beginning of one possible new era where mobile technologies will be tools of transformative museums, planetariums or science centers.

A good presenter can create a great show using even simple visuals and interacting with visitors: He may update or change content, allowing participants to come to the “same” visit program more than once. A presenter can also adjust content to answer questions and promote genuine interest, besides contributing to build a planetarium reputation.

We humbly hope these ideas, and the project described in this article, may be adapted, or be useful or, at least, may inspire other planetariums.

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REFERENCES